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by

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PHOTOPRODUCTION OF  $\pi^0$  IN THE BACKWARD DIRECTION<sup>s)</sup>

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The photoproduction of neutral pions in the reaction  $\gamma p \rightarrow \pi^0 p$  has been investigated in the backward direction ( $\theta_{\pi^0}^{cm} \approx 180^\circ$ ) at photon energies  $E_\gamma$  from 0.8 to 5.5 GeV, using a bremsstrahlung beam from the DESY electron accelerator. Only the recoil proton was detected and its momentum determined with a magnetic spectrometer. Since the lab. momentum of the recoil protons is 300 - 400 MeV/c higher than the momentum of light particles, it was possible to detect the protons in the forward direction without serious troubles from the high positron background.

The minimum energetic separation between single and multiple pion production processes is of the order of 40 MeV. Therefore, a good momentum resolution of the spectrometer was required.

The experimental setup is shown in Fig. 1. The photon beam was produced in a tungsten target of 0.06 rad. lengths and defined by three lead collimators. The flux was measured with a gas-filled quantameter. The liquid hydrogen target had a length of 30 cm.

The spectrometer produced an angular focus at a lead collimator C which defined the angular acceptance. A scintillator counter hodoscope H placed in the target image plane served to measure the particle momentum.

For photon energies below 3.4 GeV a "low momentum" version of the spectrometer was used which had a momentum dispersion at H of  $\Delta p/p_0 = 0.33 \text{ \%/cm}$  and an angular acceptance of  $\pm 5$  mrad horizontally and  $\pm 9$  mrad vertically, corresponding to a mean  $\pi^0$ -production angle  $\theta_{\pi^0}^{cm} \approx 179^\circ$ . Above 3.4 GeV a slightly different version of the spectrometer with a momentum dispersion of 0.41 %/cm was used. In this case a central stopper in the collimator C turned out to be necessary to reduce the background caused by positrons. Thus the angular acceptance was restricted to vertical angles between 4 and 18 mrad and horizontal angles between 0 and 5 mrad, corresponding to  $\theta_{\pi^0}^{cm} \approx 178^\circ$ .

The acceptance of the spectrometer was determined by a Monte Carlo calculation which took into account multiple scattering and  $(dE/dx)$ -losses in the hydrogen target and all counters. The momentum resolution ranged from 1 % FWHM at 1 GeV/c (mainly due to vary-

ing  $(dE/dx)$ -losses in the target) to 0.3 % at 5.5 GeV/c.

Events were defined by a coincidence between four scintillation counters S1...S4. Background positrons and pions were rejected by a gas threshold Cerenkov counter and a time-of-flight system. Whereas at lower momenta ( $p < 3.4$  GeV/c) there was practically no background, a 5 % background resulted at higher momenta mainly from positrons hitting magnet pole tips and shielding.

The photon density distribution was computed from the Bethe-Heitler formula taking into account the finite thickness of the converter target, the collimation angle and radiative corrections. The intercalibration of the synchrotron energy and the spectrometer momentum was determined by fitting the calculated photon density distribution, corrected for the spectrometer resolution, to the proton yields.

For  $E_\gamma < 3.4$  GeV, the  $\pi^0$ -cross sections were calculated from the proton yields using a photon energy interval of  $15 \text{ MeV} < E_\gamma^{\text{max}} - E_\gamma < 60 \text{ MeV}$ . The contribution of double pion production in this interval was less than a few per cent of the single  $\pi^0$ -yield. Empty target corrections were 10 % typically.

For  $E_\gamma > 3.4$  GeV subtraction runs with a step of  $\Delta E_\gamma = 40 \text{ MeV}$  were taken in order to eliminate the dipion contribution and the background from secondary particles. The peaks in the subtracted proton momentum spectra were fit with the calculated photon density distribution and the cross section computed from this fit.

The cross sections are shown in Fig. 2 together with results at lower energies<sup>1)</sup>. The error bars include statistical errors and errors due to the energy intercalibration. Not included is an overall systematic error of about 10 % which is mainly due to uncertainties in the acceptance and bremspectrum calculations, the nuclear absorption cross sections and the quantameter calibration. An additional error is introduced by the contribution from backward Compton scattering which is presumably small.

The structure observed in the cross section implies that resonance contributions, if not dominant, are at least comparable with non-resonant contributions. Only ( $I=3/2$ )-resonances seem to contribute strongly. We notice a shift in the position of the  $\Delta(1920)$  and the  $\Delta(2420)$  resonances which is of the order of  $\Delta E_{\gamma} \approx 100$  MeV. Similar shifts have previously been observed in the photoproduction of the  $\Delta(1236)$ ,  $N(1525)$  and  $N(1688)$ <sup>2)</sup>. The sharp dip near the  $N(2190)$  seen in backward  $\pi^-p$ -scattering<sup>3)</sup> is not present in backward  $\pi^0$ -photoproduction.

According to a quark model<sup>4)</sup>, the  $\Delta(2420)$  resonance may be excited only by magnetic photon interaction<sup>5)</sup>. Assuming that the  $\Delta(2420)$  dominates the backward cross section around 2.5 GeV an estimate of the total cross section due to this resonance is possible. A Breit-Wigner fit then implies that the radiative width  $\Gamma_{\gamma}(2420)$  is of the order of 100 keV whereas Fujimura et al.<sup>4)</sup>, assuming a special quark wave function, obtain  $\Gamma_{\gamma}(2420) = 0.3$  keV.

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### References

- 1) M. Croissiaux, E.B. Dally, R. Morand, J.P. Pahin, and W. Schmidt, Phys.Rev. (to be published).
- 2) G. Höhler, Suppl.Nuov.Cim,III, 651 (1965).
- 3) S.W. Kormanyos, A.D. Krisch, J.R. O'Fallon, K. Ruddick, and L.G. Ratner, Phys.Rev.Letters 16, 709 (1966).
- 4) K. Fujimura, T. Kobayashi, T. Kobayashi, M. Namaki, Prog. Theor.Phys. 37, 916 (1967).
- 5) Using data of Bolon et al. (Ref. 6) and our  $180^\circ$ -point, one obtains a  $\pi^0$ -angular distribution at  $E_\gamma = 2.5$  GeV and  $\theta_{\pi^0}^{\text{cm}} > 90^\circ$ , which is roughly compatible with M5 photoexcitation of a  $J=11/2$  resonance.
- 6) G.C. Bolon, D. Garelick, S. Homma, R. Lewis, W. Lobar, D. Luckey, L.S. Osborne, R. Schwitters, and J. Uglum, Phys.Rev.Letters 18, 926 (1967).

### Figure Captions

Fig. 1: Experimental setup.

QB, QA quadrupoles, MA, MB bending magnets, C lead collimator, S1,...S4 scintillation counters, H hodoscope; S1, S4 time-of-flight (TOF) counters.

Fig. 2: Dependence of  $d\sigma/d\Omega^{\text{cm}}$  for  $\gamma+p \rightarrow \pi^0+p$  on the photon energy  $E_\gamma$ . ● : this experiment; □ : Orsay (M. Croissiaux et al., Ref. 1). For convenience, some resonance positions are labelled on the graph.

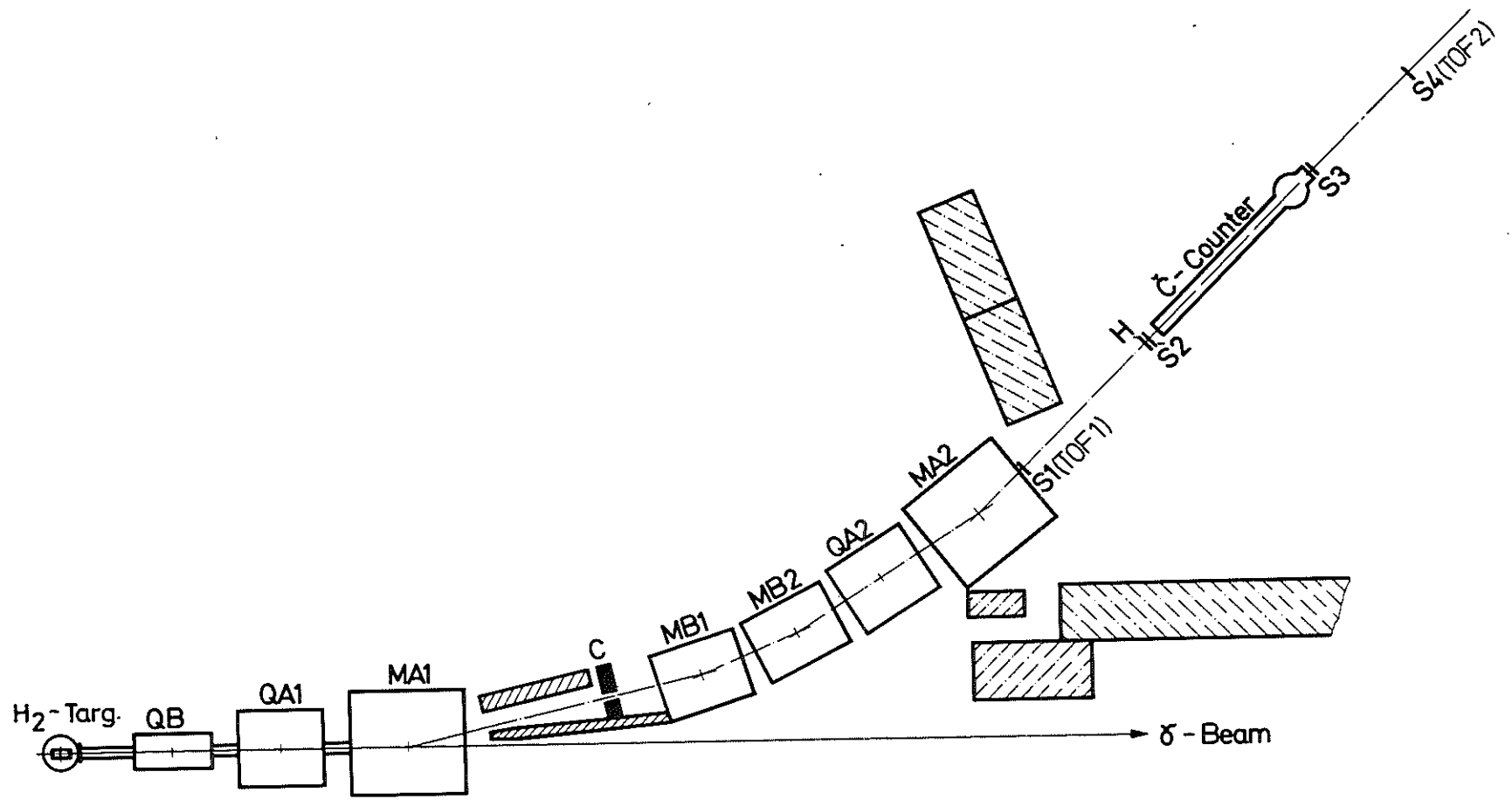


Fig.1

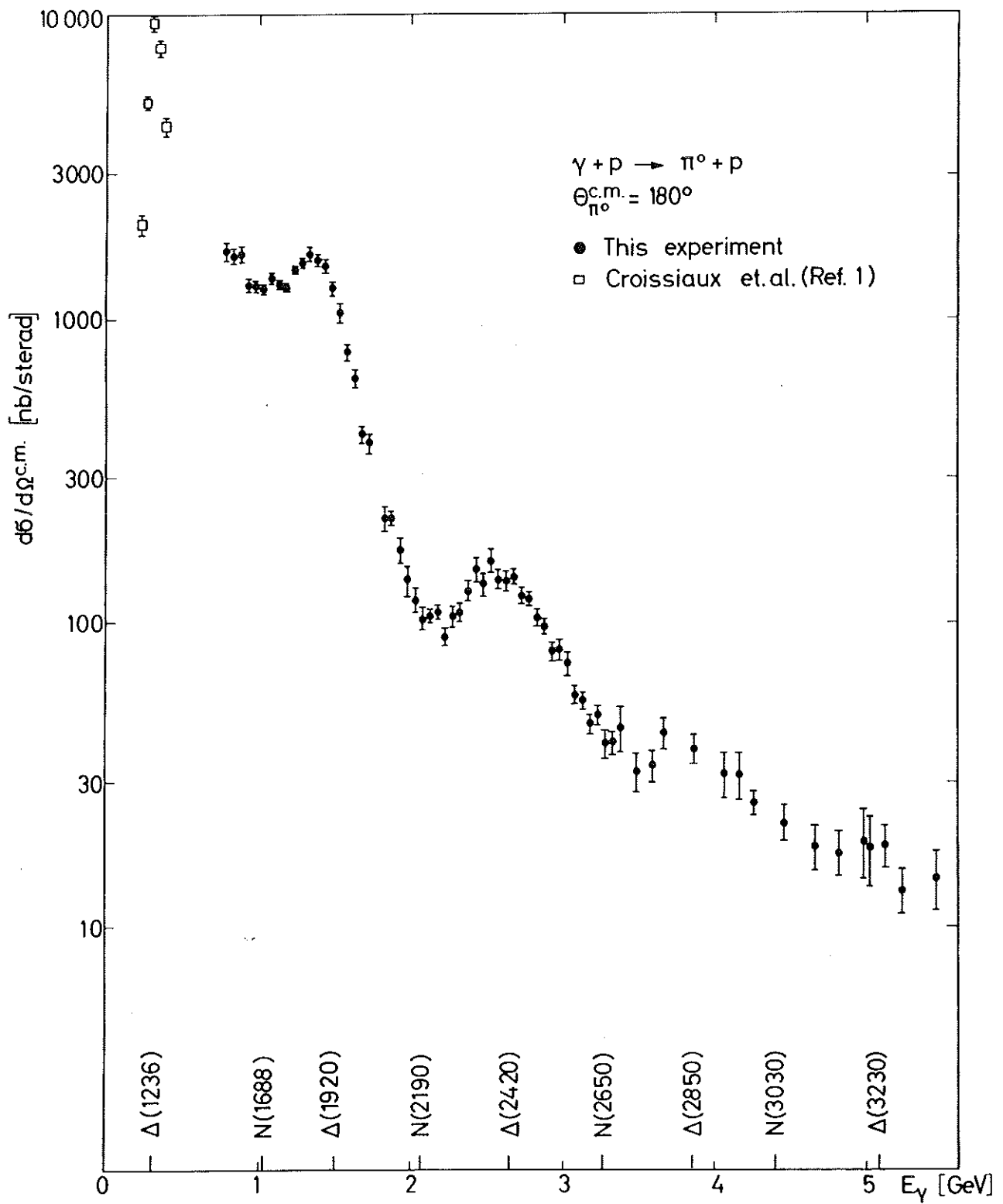


Fig. 2



